UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Andre S. Chan et al.

Application Number: 10/788,953

Filed: February 26, 2004

For: DATA RECORDING DISK DRIVE WITH NONPLANAR PLATE SURFACES FOR DAMPING OUT-OF-PLANE DISK VIBRATION

Examiner: Watko, Julie Anne

Art Unit: 2627

APPELLANTS' REPLY BRIEF

This is in response to the Examiner's Answer filed August 2, 2007.

I. PREVIOUS GROUNDS FOR REJECTION

Claims 1-3 were previously rejected under 35 U.S.C. 102(e) as being anticipated by Butt et al. (U.S. Patent No. 7,031,104 B1), hereafter referred to as "Butt." Claims 4-5, 10 and 12 were previously rejected under 35 U.S.C. 103(a) as being unpatentable over Butt in view of Machcha et al. (U.S. Patent No. 6,882,501 B2), hereafter referred to as "Machcha."

The Examiner's Answer admits that Butt is not an anticipating reference:

> "As recited in claim 1, Butt et al do not expressly show each ring comprising a plurality of discrete circumferentially spaced-apart surface features" (Examiner's Answer, page 3, lines 9-10)

Additionally, The Examiner's Answer does not address Appellants' Arguments in the Appeal Brief, instead stating that such arguments are "mooted(sic) by the new grounds for rejection".

Thus Appellants consider these previous rejections withdrawn.

II. NEW GROUNDS FOR REJECTION

Claims 1-3 are now rejected under 35 U.S.C. 103(a) as being unpatentable over Butt in view of Asano et al. (U.S. Patent No. 7,072,140 B2), hereafter "Asano". Claims 4-5, 10 and 12 are now rejected under 35 U.S.C. 103(a) as being unpatentable over Butt in view of Asano as applied to claims 1-3 above, and further in view of Machcha.

For the reasons stated below the combination of Asano with Butt fails to state a *prima facie* case of obviousness.

<u>A. The combination of Asano with Butt does not result in Appellants' invention as recited in claims 1 and 4.</u>

As shown by Figs. 2 and 3 of Asano, Asano teaches *parallel lines* of surface features 40 applied to a cylindrical surface 36a that is oriented *perpendicular to the disk surfaces* 16a and extends beyond the outer perimeters of the disks 16. These surface features may be ridges 40 (Fig. 3), pyramidal protrusions 48 (Fig. 5) or mushroom-shaped protrusions 50 (Fig. 6). These surface features are aligned as *parallel lines* because they are located on the surface of flexible adhesive tape. (Col. 7, lines 14-23). As shown in Fig. 1, this tape 38 is applied to the

disk drive's cylindrical wall 36, resulting in parallel lines of surface features that face the perimeters of the disks 16.

In contrast, Appellants' invention is a "plate having …a *planar surface facing a disk surface*, said plate surface having … radially-spaced *concentric rings*, each ring comprising a plurality of discrete *circumferentially* spaced-apart surface features." Thus, if the adhesive tape of Asano were to be applied to a surface parallel to the disk surfaces of Butt, the result would be *parallel lines of surface featur*es extending *perpendicular to a disk radius*. It is not physically possible for the adhesive tape of Asano to be applied to the disk drive of Butt, or any disk drive, in a manner that would result in "*concentric rings* …comprising a plurality of discrete *circumferentially* spaced-apart surface features", as required by Appellants' claims 1 and 4.

Because the combination of Asano with Butt does not result in Appellants' invention as recited in claims 1 and 4, a *prima facie* case of obviousness has not been established.

B. The assertions made to support the obviousness rejection are incorrect.

The Examiner's Answer incorrectly concludes that Asano is directed to the same problem as Appellants' invention. The problem addressed by Asano is *non-laminar air-flow at the cylindrical wall perpendicular to and beyond the outer perimeters of the rotating disks;* the problem addressed by Appellants' invention is *viscous shear forces above and below the surfaces of the rotating disks*. Moreover, the reason for this incorrect conclusion is the result of an incorrect technical assumption regarding these two substantially different regions of air-flow in a disk drive. Because the obviousness rejection expressly relies upon these incorrect conclusions and assumptions, it cannot stand.

The Examiner's Answer relies on the recent case of *KSR v. Teleflex*, 82 USPQ 2d 1385, 1390 (2007).

> "When faced with a finite number of predictable, known solutions to *the problem of non-laminar airflow*, one of ordinary skill in the disk drive art would have had good reason to pursue *known options within her or his technical grasp*. See KSR v. Teleflex, 82 USPQ 2d 1385, 1390 (2007). When faced with a variety of *predictable, equivalent solutions to the problem of non-laminar airflow*, one of ordinary skill in the disk drive art would had further reason to substitute *known equivalents*." (Examiner's Answer, page 4, lines 1-6) (Italics added)

> "Applying the teaching of Asano et a1 to the drive of Butt et al, when the concentric rings of Butt et a1 are replaced by discrete, circumferentially spaced-apart surface features, *it is predictable that the functioning of the rings made of discrete surface features will be the same as the rings made of continuous surface features. Specifically, concentric rings made of discrete surface features will result in laminar airflow in exactly the same way as concentric rings made of continuous surface features will result in laminar airflow.*" (Examiner's Answer, page 8, lines 11-14) (Italics added)

The italicized portions above expressly state the error of combining Asano with Butt. In Asano the problem is turbulence at the smooth outer cylindrical wall beyond the outer perimeters of the rotating disks. The placement of grooves or surface features along lines parallel to the edges of the disks reduces this turbulence by channeling the flow around the cylindrical wall and thus makes the air-flow more laminar at this cylindrical surface.

Appellants' invention is not directed to reducing non-laminar air-flow, but rather to reducing viscous shear forces. Appellants admit that the problem of non-laminar air-flow *above and below the surfaces of the rotating disks* is already solved by the prior art of damping plates with *planar* surfaces.

> "These damping plates have planar surfaces parallel to the planar surfaces of the disks and extend between the disks near their perimeter. *These planar damping plates encourage laminar air flow and thus a reduction in turbulence.* However, these damping plates also cause high viscous shear forces on the disks, which require a higher spindle-motor torque, and thus higher power consumption, to maintain the desired high rotational speed." (Applellant's specification, page 1, line 28 to page 2, line 2) (Italics added)

The problem of non-laminar air-flow *above and below the surfaces of rotating disks* is thus best addressed by *planar* surfaces, like those in the prior art damping plates. Appellants' specification states that surface features on the planar surfaces of the damping plates would actually *increase* non-laminar air-flow. This is shown in Table 1 (page 6 of Appellants' specification), where the eddy viscosity (a measure of turbulence) is *increased* from the example in row 1 (planar surfaces) to the example in row 5 (circumferential grooves).

Thus, to one skilled in the art of disk drive air-flow, surface features on a planar surface is neither a "known option within her or his technical grasp", nor a "predictable, equivalent solution to the problem of non-laminar airflow", as incorrectly asserted in the Examiner's Answer, in reliance on *KSR v. Teleflex, supra*.

The problem addressed by Appellants' invention is *not* the reduction of non-laminar air-flow above and below the rotating disks, but the reduction of viscous shear forces caused by *planar* damping plates that already minimize non-laminar air-flow.

> "... the *nonplanar* damping plates provide the ability to reduce the viscous torque, and thus the power consumption of the disk drive, with relatively minor increases in turbulence (as represented by eddy viscosity). The *nonplanar* damping plates thus provide an important design option to optimize the trade-off between power consumption and out-of-plane disk buffeting, depending on the characteristics of the particular disk drive being developed, e.g., the size, rotational speed, and power-saving requirements." (Appellants' specification, page 7, lines 1-6) (Italics added)

The non-obviousness of Appellants' invention should be apparent from the portion of Appellants' specification that refers to Figs. 6A-6B, which show the invention of claims 1 and 4.

> "Figs. 6A-6B illustrate a perspective view and cross-sectional view, respectively, of a second embodiment of the damping plate in which the *nonplanar surfaces have discrete surface features*.... While the surface features are shown in Figs. 6A-6B as patterned in concentric rings around the plate, they need not be located in such a pattern. However, *it is believed that this pattern provides concentric rings of substantially planar surfaces between the concentric rings of surface features ... which reduces the turbulent intensity along these rings*". (Appellants'' specification, page 7, lines 7-20) (Italics added)

For the reasons stated above, all the claims presently on file in the present application are in condition for allowance, and such action is respectfully requested.

Respectfully submitted,

September 22, 2007

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SUPPLEMENTAL APPENDIX B

EVIDENCE

1. U.S. Patent No. 7,072,140 B2, referred to herein as "Asano."

Appellants do not believe a copy of Asano is required to be attached as "evidence". However, it is submitted herein because of the Examiner's previous requirement that patent references relied upon in the brief are evidence that must be attached as an Appendix. In the event a copy of Asano is not required to be attached as an Appendix, Appellants' respectfully request that the Examiner delete this Supplemental Appendix rather than reject this Reply Brief and request a new Reply Brief.

US007072140B2

(12) **United States Patent**
Asano et al.

(10) **Patent No.: US 7,072,140 B2**
(45) **Date of Patent: Jul. 4, 2006**

(54) **DISK DRIVE HAVING AIRFLOW ADJUSTING MECHANISM AND THIN-PLATE MEMBER INCORPORATED THEREIN**

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(73) Assignee: **3M Innovative Properties Company**, St. Paul, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 101 days.

(21) Appl. No.: **10/484,274**

(22) PCT Filed: **Jul. 8, 2002**

(86) PCT No.: **PCT/US02/21488**

§ 371 (c)(1),
(2), (4) Date: **Jan. 20, 2004**

(87) PCT Pub. No.: **WO03/021596**

PCT Pub. Date: **Mar. 13, 2003**

(65) **Prior Publication Data**

US 2004/0184178 A1 Sep. 23, 2004

(30) **Foreign Application Priority Data**

Aug. 31, 2001 (JP) 2001-264430

(51) **Int. Cl.**
G11B 33/14 (2006.01)

(52) **U.S. Cl.** **360/97.02**; 360/97.03

(58) **Field of Classification Search** 360/97.02, 360/97.01; 720/648, 650, 651
See application file for complete search history.

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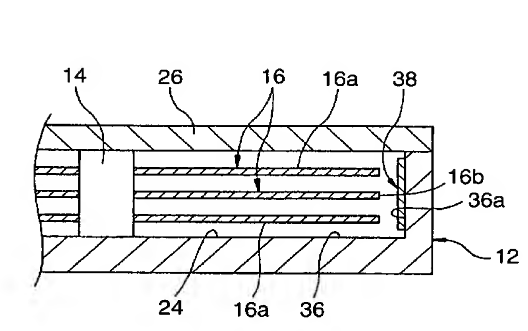
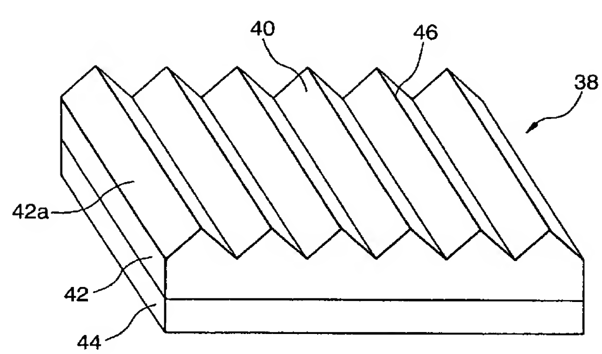
Primary Examiner—William Korzuch
Assistant Examiner—Christopher R. Magee

(57) **ABSTRACT**

A disk drive **10** includes a thin-plate member **38** fixedly attached at a desired location to an inner wall surface **36** defining a recess **24** of a casing **12**. The thin-plate member **38** includes a substrate layer having a major side on which a plurality of minute protrusions are formed and an adhesive layer attached fixedly on the back side of the substrate layer. The thin-plate member **38** is fixedly attached on the inner wall surface **36** of the casing **12** through the adhesive layer with the minute protrusions being exposed to the recess **24** of the casing **12**. The thin-plate member **38** has a flexibility permitting it to follow the shape of the inner wall surface **36** of the casing **12**. The thin-plate member **38** reduces an interfacial friction caused between the inner wall surface **36** of the casing and the airflow generated around the storage disk **16** in rotation.

11 Claims, 5 Drawing Sheets





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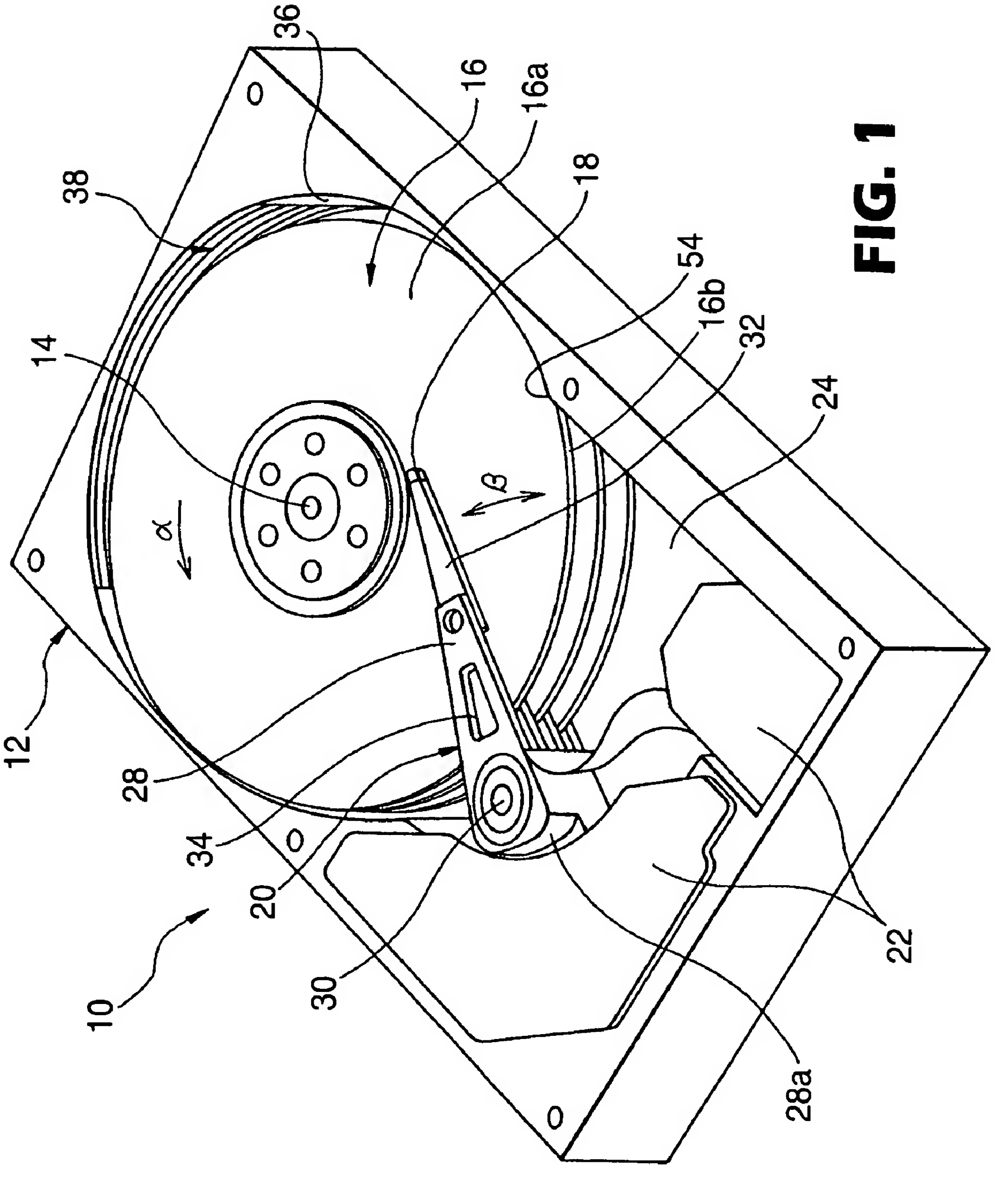

FIG. 1

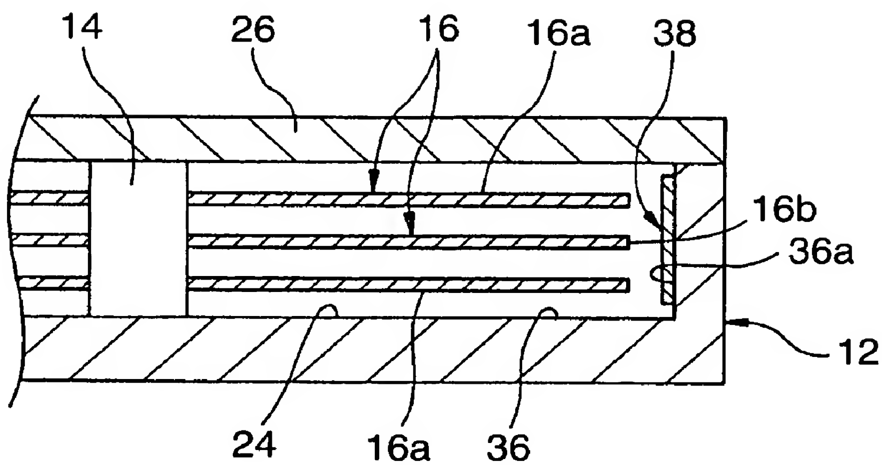

FIG. 2

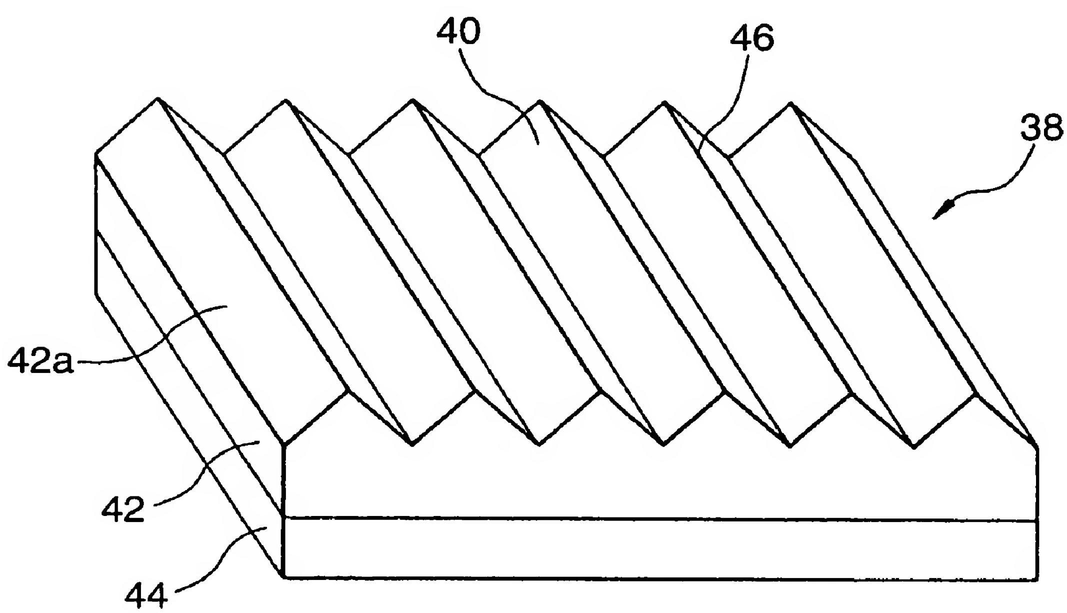

FIG. 3

FIG. 4a

FIG. 4b

FIG. 4c

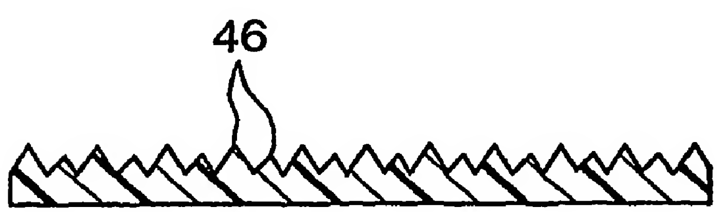

FIG. 4d

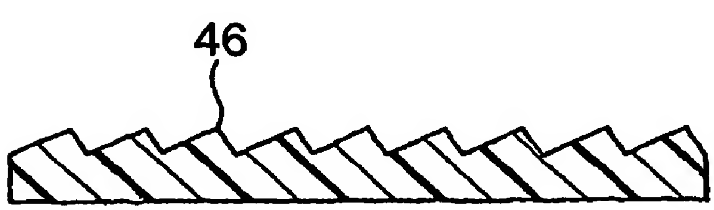

FIG. 4e

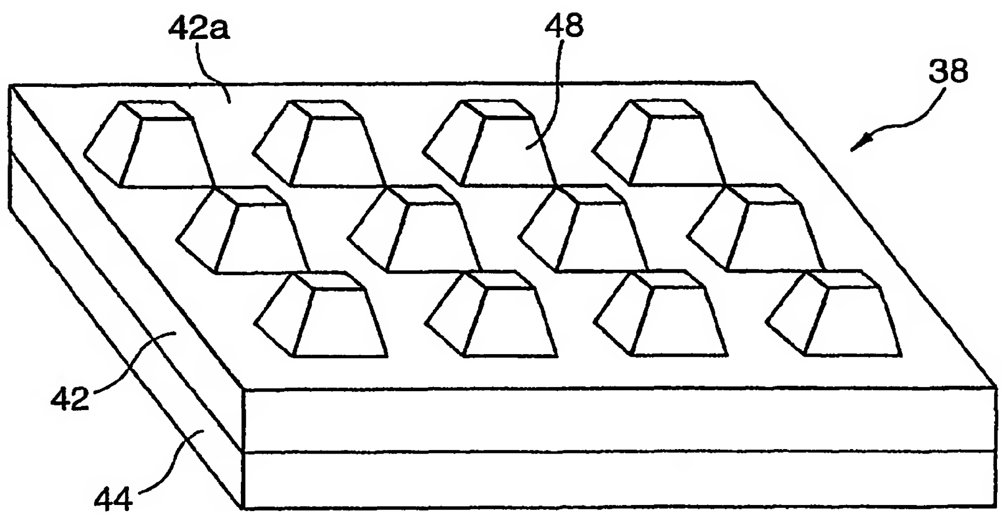

FIG. 5

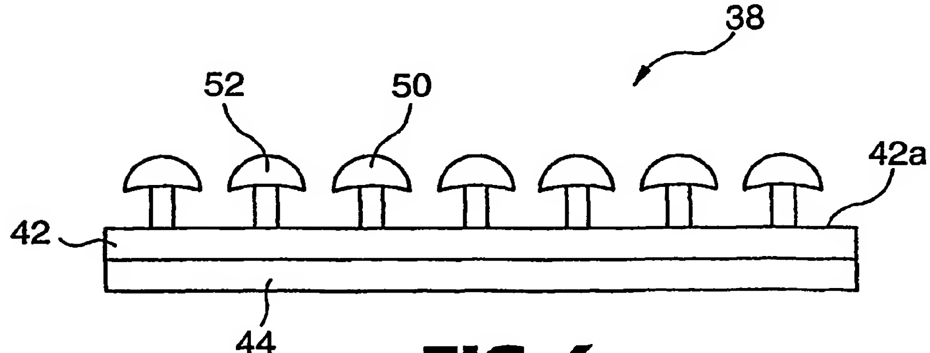

FIG. 6

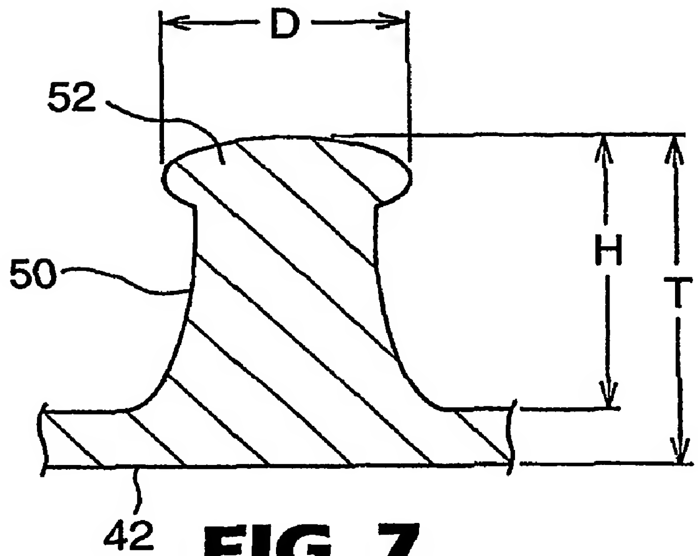

FIG. 7

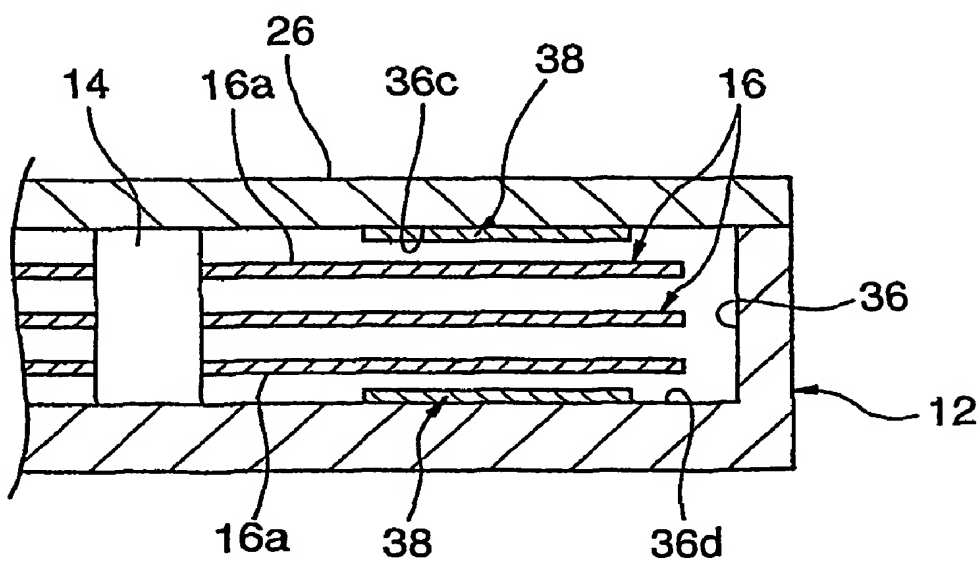

FIG. 8

DISK DRIVE HAVING AIRFLOW ADJUSTING MECHANISM AND THIN-PLATE MEMBER INCORPORATED THEREIN

This application is a 371 of PCT/US 02/21488 Jul. 8, 2002

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a disk drive for writing and reading data to and from a storage disk, and particularly to a disk drive having an airflow adjusting mechanism for adjusting the airflow generated around the storage disk when rotating at high speed. The present invention further relates to a thin-plate member incorporated, as an airflow adjusting mechanism, in such a disk drive.

BACKGROUND OF THE INVENTION

In a disk drive used as an auxiliary storage unit of an information processing system, any one of various disk-shaped storage media (referred to as the storage disk in this specification) such as a magnetic disk, an optical disk and a magneto-optic disk is rotated at high speed, while a head section is caused to perform the tracking operation following a multiplicity of recording tracks formed concentrically on the recording surface of the recording disk thereby to read and write data. The tracking performance of the head section depends on the positioning accuracy in the servo control operation of an actuator supporting the head section. Especially in recent years, with the remarkable increase in the recording density of the storage disk, demand has become increasingly high for a positioning accuracy of the actuator.

For the actuator to perform the highly accurate tracking operation, the external disturbances affecting the operation of the actuator are required to be minimized while at the same time eliminating the vibration of the storage disk as far as possible during rotation. For example, the airflow generated around the storage disk in high-speed rotation becomes turbulent by bombarding the inner wall surface of the casing of the disk drive and may cause the vibration of the actuator and the storage disk. The vibration of the actuator and the storage disk is a factor adversely affecting the head positioning accuracy and the dimensional accuracy of the gap between the head and the recording surface of the disk.

To cope with the vibration due to the airflow, various disk drives have been proposed which include an airflow adjusting mechanism for adjusting the airflow generated around the storage disk rotating at high speed. Japanese Unexamined Patent Publication (Kokai) No. 2000-348465, for example, discloses a hard disk drive having a rectification plate mounted on the inner wall surface of the casing. The rectification plate is a rigid member having the shape of a truncated cylinder partially surrounding the outer peripheral surface of the storage disk, and fixedly fitted in the cylindrical inner wall surface of the casing. The rectification plate is made of a tubular metal material, and has an inner peripheral surface in opposed relation to the storage disk, machined to form a rectification groove extending along the periphery thereof. The rectification plate smoothly guides along the rectification groove the airflow generated around the storage disk rotating at high speed thereby to reduce the effect that the vibration, etc. caused by the airflow has on the storage disk.

Also, Japanese Unexamined Patent Publication (Kokai) No. 2000-357385 discloses a CD-ROM device comprising a plurality of annular grooves formed concentrically of the

rotational axis of the disk at locations in opposed relation to the recording surface of the storage disk. These annular grooves guide, in a circular route, the airflow caused by the rotation of the storage disk thereby to alleviate the effect that the vibration or the like caused by the airflow has on the storage disk.

Japanese Unexamined Patent Publication (Kokai) No. 11-297037 discloses a hard disk drive comprising a guide groove for forcibly moving the airflow caused by the rotation of a plurality of storage disks, diametrically outward of the rotation center in the space between the storage disks. This forcible movement of the airflow contributes to the suppression of the vibration of the storage disks.

Japanese Unexamined Patent Publication (Kokai) No. 11-73756 discloses a hard disk drive comprising a plurality of rectification walls for rectifying the airflow caused by the rotation of the storage disk, which rectification walls are formed at the corners inside the casing. The rectification walls form a cylindrical enclosure wall in collaboration with each surface opposed to the storage disk and guide the airflow smoothly.

The specification of U.S. Pat. No. 4,885,652 and Japanese Unexamined Utility Model Publication (Kokai) No. 2-16474 corresponding thereto as well as the specification of U.S. Pat. No. 4,339,777 disclose a disk drive comprising an airflow guide structure for forcibly moving the airflow caused by the rotation of the storage disk, toward an air filter arranged in the casing.

In the prior art, the casing of the disk drive includes a rigid structure made of an ordinary metal material through a casting process and has a bottomed recess for stably accommodating the main essential parts of the disk drive. The conventional various airflow adjusting mechanisms described above, therefore, require some machining step for mounting an independent member such as a rectification plate or a rectification wall on the inner wall surface defining the recess of the casing. This machining process may complicate the production process or increase the production cost of the disk drive.

The object of the present invention is to provide a disk drive for writing and reading data into and from a storage disk, comprising an inexpensive and an easy-to-mount airflow adjusting mechanism for adjusting the airflow generated around the storage disk rotating at high speed thereby to effectively suppress the effect that the vibration or the like caused by the airflow has on the storage disk.

Another object of the invention is to provide a thin-plate member capable of being incorporated, as an airflow adjusting mechanism, in a disk drive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing a disk drive according to an embodiment of the invention with the casing cover removed.

FIG. **2** is a sectional view schematically showing a plurality of storage disks and a thin-plate member of the disk drive of FIG. **1**.

FIG. **3** is a perspective view showing the thin-plate member of FIG. **2** in an enlarged form.

FIG. **4** (*a*) to (*e*) are enlarged sectional views of the thin-plate members according to modifications.

FIG. **5** is an enlarged perspective view of the thin-plate member according to a modification.

FIG. **6** is an enlarged front view of the thin-plate member according to another modification.

FIG. **7** is a partly enlarged sectional view showing a preferred shape of a headed element of the thin-plate member of FIG. **6**.

FIG. **8** is a sectional view schematically showing a disk drive having the thin-plate members arranged at different locations.

SUMMARY OF THE INVENTION

In order to achieve the object described above, the invention as set forth in claim **1** provides a disk drive comprising a casing having an inner wall surface defining a recess; a rotatable storage disk arranged in the recess of the casing and having a recording surface; an actuator arranged in the recess of the casing at a location near the storage disk, the actuator carrying a head section to be opposed to the recording surface of the storage disk and causing the head section to perform a tracking operation relative to the recording surface; and an airflow adjusting mechanism for adjusting an airflow generated around the storage disk in the recess of the casing due to a rotation of the storage disk; wherein the airflow adjusting mechanism includes a thin-plate member having a flexibility permitting the thin-plate member to follow a shape of the inner wall surface of the casing, the thin-plate member including a substrate layer having a major side on which a plurality of minute protrusions are formed and an adhesive layer attached to a back side of the substrate layer opposite to the major side, the thin-plate member being fixedly attached to the inner wall surface of the casing through the adhesive layer with the plurality of minute protrusions being exposed to the recess of the casing.

The invention of claim **2** provides a disk drive as set forth in claim **1**, wherein the plurality of minute protrusions of the thin-plate member comprise a plurality of ridges extending generally in parallel to each other.

The invention of claim **3** provides a disk drive as set forth in claim **1**, wherein the plurality of minute protrusions of the thin-plate member comprise a plurality of headed elements respectively having bulging heads at distal ends thereof

The invention of claim **4** provides a disk drive as set forth in claim **1** wherein the thin-plate member is arranged at a location opposed to an outer peripheral edge of the storage disk.

The invention of claim **5** provides a disk drive as set forth in claim **1** wherein the thin-plate member is arranged at a location opposed to the recording surface of the storage disk.

The invention of claim **6** provides a thin-plate member incorporated, as an airflow adjusting mechanism, in a disk drive as set forth in claim **1**.

The invention of claim **7** provides a thin-plate member as set forth in claim **6**, wherein the minute protrusions are arranged into specific geometric patterns with flat or open areas adjacent or alternating with other minute protrusions or intrusions formed on the major surface.

The invention of claim **8** provides a thin-plate member as set forth in claim **6**, further provided with a surface having an air filtration function.

The invention of claim **9** provides a thin-plate member as set forth in claim **6**, further having a function for reducing acoustic emissions from the disk drive.

The invention of claim **10** provides a thin-plate member as set forth in claim **6**, further having at least one function selected from an anti-static function, a charge-surface function for attracting particulates and an absorb-moisture function.

The invention of claim **11** provides a thin-plate member as set forth in claim **6**, further having at least one function selected from an electromagnetic-interference reducing function and a radio-frequency-interference reducing function.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be explained in detail below with reference to the accompanying drawings. In the drawings, the same or analogous component elements are designated by the same reference numerals, respectively.

Referring to the drawings, FIG. **1** is a perspective view showing a disk drive **10** according to an embodiment of the invention with the casing cover thereof removed, and FIG. **2** is a sectional view schematically showing an airflow adjusting mechanism of the disk drive **10**. The disk drive **10** has a configuration of a hard disk drive used as an auxiliary storage unit of an information processing system such as a personal computer.

The disk drive **10** comprises a casing **12**, a plurality of (three in the drawing) storage disks **16** arranged rotatably about a common drive shaft **14** in the casing **12** and each having a recording surface **16*a***, a drive source (not shown) for rotationally drive the storage disks **16**, an actuator movably arranged in the casing **12** in the vicinity of the storage disks **16** for supporting a plurality of head sections **18** in opposed relation to the recording surface **16*a*** of the storage disks **16** and activating the head sections **18** to perform the tracking operation following (tracking) the recording surface **16*a***, and a servo mechanism **22** for driving the actuator **20**.

The casing **12** has a rigid structure fabricated of a metal material, for example, through the casting process and has a bottomed recess **24** for stably accommodating the above-mentioned main essential elements of the disk drive **10**. A cover **26** for shielding the recess **24** is mounted on the casing **12** with the main essential elements accommodated in the recess **24**.

The storage disks **16** are magnetic disks having a recording surface **16*a*** on the two surfaces thereof, and each recording surface **16*a*** is formed with a multiplicity of recording tracks (not shown) concentrically about the rotation axis. The plurality of the storage disks **16** are mounted fixedly on a common drive shaft **14** at predetermined intervals with each other in the direction along the axis in the recess **24** of the casing **12**, and rotated at high speed (in the direction indicated by arrow α) in synchronism with each other by the driving action of the drive source.

The actuator **20** includes a plurality of (four in the drawing) suspension arms **28** each extending along the recording surface **16*a*** of the storage disk **16** and rotatable about a supporting shaft. The suspension arms **28** are coupled integrally to each other at the base ends thereof and the integrally coupled portions **28*a*** are mounted on a common shaft **30**. The end of each suspension arm **28** is coupled with a head supporting plate **32**, like a spring plate, and a slider (not shown) making up the head section **18** carried at an end of each head supporting plate **32**. The plurality of the suspension arms **28** are rotated about the shaft **30** (in the direction indicated by arrow β) in synchronism with each other over a predetermined angular range by the driving action of a servo mechanism **22** in the recess **24** of the casing **12**. As a result, the head section **18** at the forward end of the head supporting plate **32** coupled to each suspension arm **28**

performs the tracking operation on the recording tracks formed on the recording surface **16***a* of the corresponding storage disk **16** thereby to write or read the data into or from the recording surface **16***a*. The actuator **20** is formed with a through hole **34** at about the central portion of each suspension arm **28** to reduce the moment of inertia of the plurality of the suspension arms **28** in operation thereby to reduce the weight of the arms **28**.

The disk drive **10** further comprises an airflow adjusting mechanism having the following structural features capable of effectively suppressing the effect that the airflow and the resulting vibration would otherwise might have on the storage disks **16**, by adjusting the airflow caused around the plurality of the storage disks **16** rotating at high speed in the recess **24** of the casing **12**.

The airflow adjusting mechanism of the disk drive **10** includes a thin-plate member **38** fixed at the desired location on the inner wall surface defining the recess **24** of the casing **12**. The thin-plate member **38**, as shown in FIG. **3**, includes a substrate layer **42** having a major side **42** formed with a plurality of minute protrusions **40**, and an adhesive layer **44** attached on the other surface of the substrate layer **38** far from the major side **42***a*. The thin-plate member **38** is fixed on the inner wall surface **36** of the casing **12** through the adhesive layer **44** with the plurality of the minute protrusions **40** exposed to the recess **24** of the casing **12**.

The thin-plate member **38** is so flexible as to be capable of following the shape of the inner wall surface **36** of the casing **12**. This flexibility is given by selecting the material and size of the thin-plate member **38** as described later. Especially in the shown embodiment, the thin-plate member **38** is arranged at a predetermined location on the side surface area **36***a* of the inner wall surface of the casing **12** in opposed relation to the outer peripheral edges **16***b* of the plurality of the storage disks **16**. Generally, the side surface area **36***a* of the casing **12** is formed in the shape of a cylinder having a radius of curvature corresponding to the radius of curvature of the outer peripheral edges **16***b* of the storage disks **16** in order to assure the smoothness of the airflow caused by the storage disks **16** in rotation. The thin-plate member **38** is fixed in this manner in a curved state smoothly following the shape of the inner wall surface **36** having a predetermined radius of curvature.

Also, in the shown embodiment, the plurality of the minute protrusions **40** of the thin-plate member **38** are formed as a plurality of ridges **46** (FIG. **3**) extending substantially parallel to each other. The thin-plate member **38** is thus set in position on the inner wall surface **36** in such a manner that the ridges **46** making up the plurality of the minute protrusions **40** extend in the direction substantially parallel to the recording surface **16***a* of the storage disks **16**.

The thin-plate member **38** is not limited to the construction shown in FIG. **3**, but may be structured in such a manner that the minute protrusions are arranged into specific geometric patterns with flat or open areas adjacent or alternating with other minute protrusions or intrusions formed on the major surface. That is, the thin-plate member **38** may optionally contain intrusions, or convex or concave surface features, on the major surface of the substrate layer, as determined by a pyramid, square, rectangular, round, one quarter circle and combinations thereof.

The thin-plate member **38** having this configuration minimizes the friction of the surface in contact with the airflow generated by the rotation of the storage disks **16** on the side surface area **36***a* of the inner wall surface **36** of the casing in opposed relation to the outer peripheral edges **16***b* of the plurality of the storage disks **16**, with the result that the airflow along the side surface area **36***a* is smoothly guided and stabilized substantially into a laminar flow. Thus, the effect that the vibration or the like caused by the airflow has on the storage disks **16** is suppressed very effectively.

The thin-plate member **38** may also provided on the major surface **42***a* of the substrate layer **42** with a surface feature having an air filtration function, either in conjunction with or separate from the airflow adjusting features. Protrusions and/or intrusions, similar to the above-described surface features, are capable of capturing or collecting particulates on the major surface of the thin-plate member **38** and the interior of a disk drive casing. From this viewpoint, chemical filtration could also be incorporated by the selection of polymers or the addition of additives such as carbon or other absorbent materials.

Also, the configuration in which the thin-plate member **38** having a sufficient flexibility is fixed at the desired location on the inner wall surface **36** of the casing through the adhesive layer **44** totally eliminates the need of machining process for mounting the thin-plate member **38** on the inner wall surface **36** of the casing **12** even in the case where the casing **12** has a rigid structure fabricated through a casting process or the like. Thus, the thin-plate member **38** simplifies the manufacturing process and reduces the manufacturing cost of the disk drive **10**.

The material of substrate layer **42** of the thin-plate member **38** is not limited, but a resinous substrate made of, e.g., polypropylene, polyethylene, acrylic resin, polyimide, polyether imide, polycarbonate or polyethylene terephthalate may be employed. A liquid crystal polymer may also be used as the material of the substrate layer. The minute protrusions **40** may be formed by, e.g., an embossing process, an extrusion process, chemical etching or ion etching, on the substrate layer **42**. Also, the adhesive layer **44** may be made of a general type of a pressure sensitive adhesive, and preferably of an acrylic adhesive. In this case, it is preferred for imparting a desired flexibility to use both the substrate layer **42** having a total thickness of 0.5 millimeter (mm) to 3.0 mm (including the height of the minute protrusions **40**) and the adhesive layer **44** having a thickness of 30 micrometer (μm) to 100 μm in an appropriate combination.

Other examples of the ridges **46** making up the plurality of the minute protrusions **40** are shown in the sectional views of FIGS. **4**(*a*) to (*e*), which are disclosed in U.S. Pat. Nos. 4,986,496, 5,069,403, 5,133,516 and 5,848,769. Desirably, in the ridges **46** of various shapes shown in FIGS. **3** and **4**, the height of each ridge **46** (the distance from the base end to the top) is 20 μm to 400 μm, the angle of the V-shaped base end crossing (i.e. the valley) is 15° to 140°, and the interval between the tops of adjacent ridges **46** is 20 μm to 400 μm. The ridges **46** having any of the shown shapes can exhibit an effective function of rectifying the airflow by securing the correct directivity of the thin-plate member **38** on the inner wall surface **36** of the casing **12**.

The plurality of the minute protrusions **40** formed on the substrate layer **42** of the thin-plate member **38** are not limited to the above-mentioned ridges **46** but may be configured of, for example, pyramidal protrusions **48** shown in FIG. **5** or mushroom-shaped headed elements **50**. In any case, the plurality of the minute protrusions **40** exhibit the above-mentioned function of rectifying the airflow generated around the storage disks **16** rotating at high speed, by fixing the thin-plate member **38** in an appropriate direction on the desired portion of the inner wall surface **36** of the casing **12**. As a result, the stabilization of the airflow is

promoted and the effect that the vibration or the like caused by the airflow has on the storage disks **16** is effectively suppressed.

Especially, the headed elements **50** each having a bulging head **52** at the end are known to exhibit a superior effect of rectifying the airflow. In this case, the headed elements **50** advantageously have a section in the shape shown in FIG. **7**. As an example of the sizes of the various parts of the substrate layer **42** having the headed elements **50** of this shape described above, the diameter D of the head **52** is 0.300 mm, the height H of the headed element **50** is 0.325 mm and the total thickness T of the substrate layer **42** is 0.44 mm.

In the case where the plurality of the minute protrusions **40** are formed of ridges **46**, the material that can be preferably employed for the substrate layer **42** of the thin-plate member **38** includes, for example, a tape with protrusions (Model B-100) that can be acquired from Minnesota Mining & Manufacturing (Minnesota, USA). In the case where the plurality of the minute protrusions **40** are the headed elements **50**, on the other hand, a tape with headed elements (Model CS-200) that can be acquired from Minnesota Mining & Manufacturing (Minnesota, USA) can be employed.

The thin-plate member **38** having the aforementioned configuration can alternatively be arranged, as shown in FIG. **8**, at a predetermined location on the bottom surface area **36***b* of the inner wall surface **36** of the casing **12** in opposed relation to the lower recording surface **16***a* of the storage disk **16** located at the lower end or at a predetermined location of the top surface area (the reverse side of the cover **26**, for example) of the inner wall surface **36** of the casing **12** in opposed relation to the upper recording surface **16***a* of the storage disk **16** located at the upper end. Also in this configuration, the thin-plate member **38** works to minimize the friction of the surface in contact with the airflow generated by the rotation of the storage disks **16** on the bottom surface **36***b* or the top surface area **36***c*, as the case may be, of the inner wall surface **36** of the casing in opposed relation to the recording surface **16***a* of the plurality of the storage disks **16** and thereby stabilizes the airflow substantially into a laminar flow, whereby the effect that the vibration or the like caused by the airflow has on the storage disks **16** can be very effectively suppressed.

Further, the thin-plate member **38**, due to its own flexibility, can be fixedly attached in a curved state to smoothly fit a deformed inner wall surface **36** (such as the portion designated by reference numeral **54** in FIG. **1**, for example) not conforming with the radius of curvature of the outer peripheral edges **16***b* of the storage disks **16** or the surface of each component part arranged in the recess **24** of the casing **12**. Also, even in a disk drive of a different type having built therein storage disks of different radii of curvature (hence, different diameters), the thin-plate member **38** of the same configuration can be widely used and arranged at the desired location in the casing.

The thin-plate member according to the present invention may also have a function for reducing acoustic emissions from the disk drive. With fluid bearing on disk-driving spindles in the disk drive, airflow noise is becoming a dominant noise feature. In this respect, the thin-plate members can reduce noise generated by changing airflow characteristics of the surface, and/or absorbing and/or dissipating acoustic noise generated in the disk drive.

Preferable embodiments of the invention have been described above. The present invention, however, is not limited to the configurations of the shown embodiments, but can be variously modified or changed without departing from the scope of the claims. For example, the disk drive and the method of manufacturing it according to the present invention are applicable to disk drives having storage disks such as optical disks or magneto-optic disks other than magnetic disks.

Furthermore, the thin-plate member may have at least one function selected from an anti-static function, a charge-surface function for attracting particulates and a moisture absorption function. Also, the thin-plate member may have at least one function selected from an electromagnetic-interference reducing function and a radio-frequency-interference reducing function.

EXAMPLE

In a 8.89 cm (3.5-inch) hard disk drive having the basic configuration shown in FIG. **1**, the storage disks **16** are rotated at 10000 rpm, and the vibration in a vertical direction (along the axis of the drive shaft **14**) of the storage disk **16** located at the upper end was measured with a laser displacement gauge for both the structure according to this invention (FIG. **2**) having the thin-plate member **38** mounted on the side surface area **36***a* of the inner wall surface **36** of the casing and the conventional structure lacking the thin-plate member **38**. The point of measurement was set at the diametrical center of the recording surface **16***a* of the storage disk **16**. The two types of thin-plate members **38** were used, one including the substrate layer **42** formed with the minute protrusions **40** configured of a plurality of ridges **46** (sample **1**) and the other including the thin-plate member **38** having the substrate layer **42** formed with the minute protrusions **40** made up of a plurality of headed elements **50** (sample **2**). As a result, the vibration of 1.71 μm in terms of amplitude occurred in the vertical direction in the storage disk **16** at the upper end of the conventional structure, whereas the vibration amplitude for the structure according to the invention was suppressed to 1.33 μm for sample **1** and 0.87 μm for sample 2.

As evident from the foregoing description, according to this invention, there is provided a disk drive for writing and reading data into and from storage disks, wherein a highly reliable airflow adjusting mechanism can be mounted inexpensively and easily, which is capable of effectively suppressing, by adjusting the airflow caused around the storage disks rotating at high speed, the effect that the vibration or the like caused by the airflow has on the storage disks.

What is claimed:

1. A disk drive comprising:

a casing having an inner wall surface defining a recess;

a rotatable storage disk arranged in said recess of said casing and having a recording surface;

an actuator arranged in said recess of said casing at a location near said storage disk, said actuator carrying a head section to be opposed to said recording surface of said storage disk and causing said head section to perform a tracking operation relative to said recording surface; and

an airflow adjusting mechanism for adjusting an airflow generated around said storage disk in said recess of said casing due to a rotation of said storage disk, said airflow adjusting mechanism comprising a thin-plate member having a flexibility that permits said thin-plate member to follow a shape of said inner wall surface of said casing, said thin-plate member comprising a substrate layer having a major side and a back side opposite to said major side, a plurality of minute protrusions formed on said major side and an adhesive

layer attached to said back side of said substrate layer, said thin-plate member being fixedly attached to said inner wall surface of said casing through said adhesive layer with said plurality of minute protrusions being exposed to said recess of said casing.

2. The disk drive of claim **1**, wherein said plurality of minute protrusions of said thin-plate member comprise a plurality of ridges extending generally in parallel to each other.

3. The disk drive of claim **1**, wherein said plurality of minute protrusions of said thin-plate member comprise a plurality of headed elements, each headed element respectively having bulging heads at distal ends thereof.

4. The disk drive of claim **1**, wherein said thin-plate member is arranged at a location opposed to an outer peripheral edge of said storage disk.

5. The disk drive of claim **1** wherein said thin-plate member is arranged at a location opposed to said recording surface of said storage disk.

6. The thin-plate member incorporated, as an airflow adjusting mechanism, in a disk drive of claim **1**.

7. The thin-plate member of claim **6**, wherein said minute protrusions are arranged into specific geometric patterns with flat or open areas adjacent or alternating with other minute protrusions or intrusions formed on said major surface.

8. The thin-plate member of claim **6**, further provided with a surface having an air filtration function.

9. The thin-plate member of claim **6**, further having a function for reducing acoustic emissions from said disk drive.

10. The thin-plate member of claim **6**, further having at least one function selected from an anti-static function, a charge-surface function for attracting particulates and a moisture absorption function.

11. The thin-plate member of claim **6**, further having at least one function selected from an electromagnetic-interference reducing function and a radio-frequency-interference reducing function.

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